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EXECUTIVE SUMMARY

A STUDY OF PROCESS METALLURGY R&D OPPORTUNITIES IN ONTARIO

R. Reesor, R. Bergman and C.J. Simpson
Process Metallurgy, Metallurgical Research Department

A small study team was assembled at Ontario Hydro Research Division to assess R&D opportunities in the field of process metallurgy which would be pertinent to the future operation of Ontario-based metals producers. Information was assembled through visits to a diverse group of industries in the Province.

It has been concluded that a number of R&D oppotunities do exist. These opportunities mainly involve new applications of various electro-technologies to process metallurgy. It is recommended that Ontario Hydro support new initiatives in process metallurgy in two ways. Funding should be provided for R&D projects either at universities or at the metals producers themselves and a small research group should also be established at Research Division to carry out in-house projects. Acquisition of a 200 kW electric furnace, which is essential for the initial in-house project, is also recommended. It would also be useful for a number of future R&D projects and should be located at the Lakeview Plasma R&D Facility. It is recommended that the initial in-house project be undertaken in collaboration with Falconbridge Limited to examine problems which are expected to arise in their electric furnaces when they shift to a new mode of operation for reducing SO_2 emissions. The project would be aimed at identifying the optimum method for eliminating these electric furnace problems and helping Falconbridge Limited maintain a competitive position in world markets.

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To Dr. D. Mills
Director of Research

A STUDY OF PROCESS METALLURGY R&D OPPORTUNITIES IN ONTARIO

R. Reesor, R. Bergman and C.J. Simpson

1.0 INTRODUCTION & BACKGROUND

The Process Metallurgy industry is a major employer in Ontario and contributes much to the financial well-being of the Province. This is especially so for the steel industry concentrated in Hamilton and Sault Ste.Marie and the copper and nickel industries concentrated in the Sudbury area. Within the past 10 years, and especially the last 5 years, these producers have fallen upon hard times. Shrinking markets and increased foreign competition have led to production and staff reductions. The general statement can be made that these Ontario-based metals producers will have to adopt new technology to remain viable operations and that failure to do so will most probably result in further cutbacks in staff and production or, in some cases, closure. This is especially the case for the integrated steel plants in Ontario. The nickel and copper producers in the Sudbury area are faced with similar difficulties and in addition must make very expensive changes to their plant operations to allow them to conform to new Provincial Legislation pertaining to the environment, specifically SO_2 emissions.

Over the past 5 years there have been significant changes in the nature of R&D devoted to utilization of electrical energy carried out at the Research Division of Ontario Hydro. Industrial utilization has grown significantly in this 5-year time frame. Many new programs have emerged to examine the use of and develop the technology for industrial use of microwave heating, induction heating, plasma heating, heat pumps, etc. This work has been primarily carried out within the Electrical Research Department and to a great extent is device oriented (eg a plasma torch is a device which can be used to put electrical energy in the form of high temperature heat into a system). The Research Division expertise for these programs lies mainly in the devices as opposed to the processes. As an example, the Research Division's 80 kW plasma torch has been used for preliminary experiments involving metallurgical reduction reactions but no process metallurgy expertise has been devoted to the work. The reason for this is the following: The Metallurgical Research Department, comprising nearly 100 staff members, is one of the largest metallurgical research groups in Canada. The research carried out within this Department is entirely physical metallurgy (deformation, welding, corrosion, fracture etc) - there are no staff in the Research Division working in the area of extractive

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metallurgy or process metallurgy. The reasons for this are entirely historical, the Metallurgical Research Department has evolved and grown in order to serve Ontario Hydro's needs in the metallurgy area - these needs up to now were entirely in the field of physical metallurgy.

Within the past 3 years Ontario Hydro has placed new emphasis on the marketing of electrical energy and a Marketing Branch has been created. New emphasis has been placed on the marketing of electrical energy for industrial use. The metals producers of Ontario are seen to be major consumers of electrical energy and among the most important electrical customers in the Province. Continued economic health of these customers is important to both Ontario Hydro for the large electrical loads which they represent and to the Province of Ontario for the jobs that they provide.

With all of the above serving as background, it was felt highly appropriate to undertake a study to identify R&D opportunities within the process metallurgy industry in Ontario. The study was also to examine whether or not there is justification for establishing a process metallurgy research group and program at Research Division and/or for Ontario Hydro supporting process metallurgy R&D at external organizations (Ontario universities, industrial laboratories).

It was decided that the best way to carry out the study was to form a small team with background knowledge in process metallurgy and to visit Ontario based process metallurgy industries.

It was also decided that a process metallurgy R&D opportunity should not necessarily have to be directly tied to increased use of electrical energy. Research programs which could lead to more efficient use of electrical energy in an existing electrically driven metallurgical process should also be of interest. Additionally, although use of electrical energy is of interest to Ontario Hydro, an R&D opportunity might not necessarily have to be directly associated with use of electrical energy. The operative words should be "productivity" and "what is in the best interest of the industrial customer". Thus the key for Ontario Hydro making significant contributions through R&D in process metallurgy is seen to be identifying, selecting and assisting R&D projects which can aid the competitiveness of Ontario based process metallurgy industries and either create new or sustain existing jobs in the Province.

1.1 Visits and Contacts Made

The Ontario companies either visited or contacted are listed in Table 1.

In most cases a trip report or summary of discussion was made. For the purpose of providing additional information these documents are included in Appendix I.

TABLE I - COMPANIES OR ORGANIZATIONS VISITED OR CONTACTED

1. Companies Visited

Algoma Steel
Atlas Specialty Steel Division
Dofasco
Eldorado Resources
Falconbridge Ltd
Kidd Creek
Chromasco
Stelco
Fahramet Foundry
Tanoak Enterprises

2. Contact with Companies & Organizations

Pamour Porcupine Mines
Titan Titanium International
McMaster University
Hatch Associates
Prochem
University of Toronto
Canadian Cyanamide
INCO
Exolon

2.0 RESEARCH AND DEVELOPMENT OPPORTUNITIES

A number of R&D opportunities were identified during the company visits and discussions with others active in process metallurgy R&D. An overview is presented first followed by a summary of the R&D opportunities identified at the various companies. Copies of the visit reports, containing detailed information, are included in Appendix 1.

2.1 Overview of R&D Opportunities

Electromagnetic or gas stirring of the matte in the electric smelting furnace was of particular interest to Falconbridge Limited as part of their program to develop an economical method for reducing SO_2 emissions from the smelter to the atmosphere.

Induction heating of slabs, strip and tube was a common theme for the steel industry (marketing opportunities). Induction heating of hot metal in a large mixer, was also of interest. Several potential applications for microwave drying and heating were outlined. Considerable interest was expressed in OHRD's plasma technology program.

A wide range of potential R&D projects was identified ranging from pumping of corrosive slurries to optimizing electro-refining and winning processes. Comments were also received relating to the fact that a great deal of emphasis has been placed on developing plasma technology in Canada and finding applications for it, but that there are no accessible electric arc furnaces in the 200 to 500 kVA power range available to support the rather large electric furnace based industry in Ontario. It was suggested that Ontario Hydro could take some initiative in this area.

It is believed that only a limited number of R&D opportunities were identified through the short visits to the industry. Many more will surface if an ongoing contact is maintained between OHRD and the metallurgical industry on the technical level.

2.2 Identified R&D Opportunities By Company

R&D opportunities identified during the company visits are presented by company and listed in order of perceived priority. No attempt has been made to assess their technical and economical feasibility and merit at this point. Also included for the sake of completeness, are items uncovered during the visits which are marketing opportunities rather than R&D opportunities. These opportunities may require consulting expertise currently not available within Ontario Hydro.

2.2.1 Falconbridge Limited: Falconbridge has limited in-house facilities. It makes extensive use of outside consultants and contract research at universities.

1. Control of the metal build-up (through phase separation following deeper roasting) on the hearth of the electric furnace by electro-magnetic or gas stirring of the matte to minimize temperature gradients in the matte-slag system.

2. Development of remote sensing equipment capable of monitoring the metal build-up on the hearth of the electric furnace.

3. Development of nickel electro-winning cells requiring a low capital investment and operating cost.

4. Drying of copper concentrate filter cake from 12 to 8% moisture using electro-technology.

5. Development of a hot electrostatic precipitator capable of operating at temperatures in excess of 350°C.

6. Ladle and converter shell heating by plasma torch.

7. Thawing of stored tailings for retrieval during the winter months.

8. Improvements to the underground operation of mobile electrical equipment.

2.2.2 Kidd Creek Mines Ltd: Kidd Creek's R&D capabilities are limited. Outside consultants and contract R&D, primarily at universities are used.

1. Improvements to the current efficiency in the zinc electro-winning circuit.

2. Improved control of bonding between the zinc deposit and the aluminum mother plate during electro-winning of zinc.

3. Reduction of nodule formation on copper cathodes during electro-refining with emphasis on the effect of electromagnetic forces.

4. Application of electrical heating to zinc ingot molds to reduce the incidence of shrinkage cavities and pipes.

5. Development of pumping systems for molten zinc.

6. Drying of ore or concentrates by microwave energy or the application of other forms of electrical energy.

7. Development of direct heating methods for electrolytes to overcome fouling problems associated with heat exchangers.

8. Development of pumping systems without moving parts to handle abrasive and corrosive slurries. Can this be done through electromagnetic forces?

9. Development of methods for descaling of pipe lines and heat exchangers.

10. Examination of the applicability of plasma technology for the treatment of lead precipitates.

2.2.3 Eldorado Resources Ltd: Eldorado has well equipped research facilities and a competent staff.

1. Application of auxiliary microwave heating to the uranyl nitrate decomposition pots to increase their capacity.

2. Development of a processing method for magnesium fluoride, which results from the production of uranium metal, for the removal of residual amounts of uranium to render the material safe for disposal or sale.

3. Provision of assistance in developing a method for reducing UF4 and UF6 to metallic uranium by plasma technology.

4. Optimization of the magnetic properties of the neodymium-boron-iron permanent magnet alloy.

2.2.4 Atlas Specialty Steel Division: Atlas Steel does little in-house R&D. They purchase most of their technology on a turnkey basis.

1. Assessment of and support to methods development for treating plant dusts to render them safe for disposal.

2. Induction heating of slabs. This is a longer term project since Atlas proposes to install a continuous caster in the next two years (marketing opportunity).

2.2.5 The Algoma Steel Corporation Ltd: Algoma does very little in-house R&D. They rely heavily on purchased technology.

1. Determination of the advantages and disadvantages of electromagnetic stirring in the molds of continuous casters.

2. Examination of the feasibility of induction heating of seamless steel tube shells for equalizing their wall temperatures to improve their drawability.

3. Development of reliable temperature measurement methods for steel on the run-out table.

4. Determination of the relative merits of various vacuum pumping systems used in ladle degassing systems.

5. Determination of the relative merits and applicability of Ar, N_2 and CO_2 stirring of steels.

2.2.6 Dofasco: Dofasco has increased their R&D capabilities through the acquisition of staff and equipment. The main R&D emphasis is on product quality.

1. Induction heating of slab and strip edges to improve the temperature uniformity of the metal and thus improve its rolling characteristics.

2. Dofasco has expressed an interest in obtaining assistance from OHRD in the commissioning of their new R&D equipment, including training of their staff, to be able to make effective use of it with the minimum lead time.

3. Assistance in evaluating and adapting induction heating to hot metal mixers for potential installation at Dofasco.

2.2.7 Chromasco Ltd: Chromasco has a small R&D group located at their plant facilities in Haley. It is responsible for process improvements and the development of new products.

1. Increased productivity of the magnesium retorts through improved heat transfer to the charge. Several potential approaches to achieving this were tabled.

2.2.8 Tanoak Enterprises, Barrie: This company has no R&D facilities.

1. Thermal reclamation of foundry sand using plasma technology.

2.2.9 INCO: Inco has extensive, well equipped and staffed R&D facilities both at Copper Cliff and at Sheridan Park.

1. Conversion of nickel metal powder to soluble nickel oxide through the application of plasma technology.

2. Fusion of automotive catalysts for the recovery of precious metals.

3. Process vessel and ladle preheating using plasma technology.

4. Processing of dust and sludges from the furnace dust collection systems for the selective removal of undesirable impurities and recovery of pay metals.

5. Application of plasma technology to the TBRC (Top Blown Rotary Converter).

6. Heating of weak SO_2 gas entering the conversion section of the sulphuric acid plant by plasma technology.

7. Optimizing the energy efficiency in their Ni electro-winning cells.

2.2.10 Stelco: Stelco operates a research facility to assist in the commissioning and process optimization of new technologies. They carry out a lot of process modelling in order to optimize operating parameters.

1. Electro-magnetic containment of liquid metal to reduce refractory contamination.

2. Heating of billets for temperature homogenizing and edge heating using induction coils.

3. An auxiliary heat source for the tundish to reduce the degree of superheat required in the ladle.

4. Laser spectroscopy for on-line chemical analysis of molten metal.

5. Slag chemistry modifications (ie foamy slags).

6. LB Project, a new approach to hot metal production.

3.0 OPTIONS FOR ONTARIO HYDRO RESEARCH DIVISION

The options available to OHRD with respect to supporting the metallurgical process industry through R&D initiatives are discussed and suggestions are made as to the action to the taken.

Three basic options for action are available to OHRD, namely:

1. Take no action.

2. Establish integrated process metallurgy R&D facilities and program at OHRD.

3. Support External Research and Development Programs.

3.1 Take No Action

The metallurgical process industries in Ontario are experiencing difficult economic conditions as a result of an oversupply of metals on the world market, depressed metal prices caused primarily by low labour cost in the third world countries and government support of these operations to ensure the supply of foreign currency. Canada cannot match these low labour rates. It must therefore improve its technology if it wants to remain competitive. Since most of the companies are in a difficult financial position, and therefore unable to carry out the necessary research to improve their technology to a point where they can become fully competitive, they require external assistance. Government R&D funds are more difficult to obtain than in the past. Therefore, another source of R&D support has to be found. Since a large number of the metallurgical processing companies are significant consumers of electrical energy, and hence customers of Ontario Hydro, it appears appropriate that OH provide R&D support to this segment of Ontario's industry. Failure to do this may lead to the demise of some of these companies, and hence the loss of OH's customers and jobs in Ontario, particularly in the North which has already been hard hit.

A close technical relationship between OH and the metallurgical process industry will ensure that OH is fully conversant with new developments in this industry, and that it will be therefore in a good position to influence the adoption of the electrical energy over other forms of energy based on sound technical considerations.

Based on the above it has to be concluded that support of the metallurgical process industry by OH is highly desirable, if not mandatory.

3.2 Establish Integrated Process Metallurgy R&D Facilities and Program at OHRD

As a result of recent visits made to a number of companies and discussions held with others associated with and knowledgeable in process metallurgy, a wide range of potential research projects was identified which could be carried out with assistance from OHRD. If all these projects were to be carried out at the OHRD facilities, a very substantial addition of staff and equipment would be required at a cost that would most likely run into several millions of dollars. This expenditure would be difficult to justify.

For OH to be successful in its support of metallurgical process R&D, it should not cover the broad field of process metallurgy, but focus in on one area which is directly related to OH's core business.

It was suggested that OHRD should give serious consideration to establishing an electric arc furnace R&D facility in support of Ontario's smelting and melting industry. Such facilities are not available to the industry in Ontario at present.

3.3 Support External Research and Development Programs

Another option for Ontario Hydro to support the metallurgical process industry is to adopt the contracting out approach. In this case valid projects would be carried out by commercial research organizations, university laboratories or consulting firms or at the individual industries. This approach requires that OH has process metallurgists on staff who can asssess proposed projects, manage the projects, monitor their progress and work in close co-operation with the contractor and client.

4.0 RECOMMENDED COURSE OF ACTION

4.1 Process Metallurgy R&D Program

The recommended course of action for Ontario Hydro is that of establishing a Process Metallurgy R&D Program at Research Division. The R&D Program should involve both in-house research projects and contracted out research projects; the latter would be done at universities or at Ontario industries. In essence it is recommended that the OHRD R&D program be a combination of the options described in 3.2 and 3.3.

4.2 Process Metallurgy Unit at OHRD

In order for OHRD to have a Process Metallurgy R&D Program it will be necessary to create a new staff unit with technical background and capability in process metallurgy. It is suggested that the absolute minimum size for "critical mass" in such a unit is a group of three professional and two technical support staff. Initially the group should have the status of an OHRD project unit. The new unit should be part of the Metallurgical Research Department and report to the Manager of that Department through a Supervisor (to be initially supplied on a part-time basis by Divisional Projects Department).

This new research unit could make extensive use of specialized equipment which already exists within OHRD (metallographic facilities, X-ray equipment, SEM, TEM, computing services, general chemical analytical services, etc). Some additional equipment would have to be acquired however. This is more fully described in 4.4.

4.3 Potential Contract-Out and In-House Projects

A summary of potential Contract-Out and In-House projects has been prepared. This summary is based on visits made and discussions held with representatives of various companies. The projects are not necessarily listed in order of priority, since at this time insufficient information is available to assign a reliable ranking to the projects. Feedback will also be sought from other OH Divisions before priority judgements are made. When setting priorities, the following factors will have to be considered:

- Technical feasibility;
- Probability of success;
- Resources available;
- Cost benefit versus estimated project cost;
- Political considerations.

Before funds are committed to a project a detailed project analysis will have to be carried out in close co-operation with the potential client or clients requiring the information or test results in support of their operations.

4.3.1 Summary of Potential Contract-Out Projects

1. Development of nickel electro-winning cells requiring a low capital investment and operating cost.

2. Plasma ladle and converter shell heating in non-ferrous smelters.

3. Improvements to the current efficiency in the zinc electro-winning process.

4. Improvements in the bonding between zinc deposits and the aluminum mother plate during electro-winning of zinc.

5. Application of electric heating to zinc ingot molds to improve metal yield by reducing the incidence of shrinkage cavities and pipes.

6. Development of a processing method for removing small amounts of uranium from magnesium fluoride resulting from the production of uranium metal.

7. Assessment of and support to method development for treating dust from steel and non-ferrous metals plants to render them safe for disposal. (Already in hand through PEAR Project).

8. Induction heating of slabs and strip to improve their temperature uniformity for improved rolling characteristics.

9. Determination of the advantages and disadvantages of electro-magnetic mold stirring in continuous casting of steel.

10. Development of reliable temperature measurement methods for steel shapes or plate on the run-out table.

11. Determination of the relative merits of various vacuum pumping systems employed in ladle degassing of steel.

12. Heating of weak SO_2 gas entering the conversion section of the sulphuric acid plant by plasma technology.

13. Application of plasma technology to the TBRC.

4.3.2 Summary of Potential In-House Projects

1. Electric furnace smelting studies in support of Falconbridge Ltd SO_2 emission control project.

2. LB Project, a new approach to hot metal production.

3. Development of remote sensing equipment capable of measuring a metallic build-up on the electric furnace hearth.

4. The role of electromagnetic forces on nodule formation during electro-refining of copper in the Kidd Creek jumbo tanks.

5. Application of microwave energy to ore and concentrate drying.

6. Development of electromagnetic heating methods for electrolytes to overcome fouling problems occurring in heat exchangers.

7. Reduction of UF4 and UF6 by plasma technology.

8. Assistance to Dofasco in commissioning of new R&D equipment and training of staff to use it effectively.

9. Fusion of spent automotive catalysts for the recovery of precious metals.

10. Conversion of nickel metal powder to soluble nickel oxide using plasma technology.

11. New electric retort for Mg reduction.

12. Thermal reclamation of foundry sand using plasma technology.

13. Studies on nitrogen-free blast furnace for an Ontario blast furnace application.

4.4 Facilities for In-House Projects

Options available to Ontario Hydro with respect to R&D support of the metallurgical industry were discussed in some detail under section (3.0). The most attractive option for OH to support the metallurgical process industry consists of three elements, namely: adoption of the contracting-out approach, performing R&D in existing facilities and establishing one new in-house specialized facility not presently available to the metallurgical industry in Ontario. This facility has been identified as a multi-purpose electric arc furnace facility capable of meeting the needs of the ferrous and non-ferrous metallurgical industry. It is envisaged that this facility will be used by OHRD, outside companies and universities in collaboration with OHRD staff.

While no attempt has been made to give a final ranking of priorities for the potential in-house projects suggested in 4.3.2, it is suggested that one project involving electric furnaces and SO_2 abatement is particularly appealing and should have high priority. This project could make use of a new electric furnace facility.

Falconbridge Ltd has expressed serious interest in utilizing such a furnace in the near future as part of their program to be able to meet pollution abatement requirements. The furnace will be used to determine the operating conditions required for maintaining satisfactory metal recoveries at low SO_2 emissions from the plant at a controllable metal build-up on the furnace hearth. They propose to investigate magnetic or gas stirring of the matte phase as a means of controlling the build-up on the furnace hearth. The alternative is to use more electrical energy to run their furnaces at high temperatures. This can result in higher operating costs, refractory problems and reduced competitiveness.

The following facilities are required to carry out the smelting and melting investigations envisaged:

1. Single phase electric arc furnace.

2. Transformer; Rating:

KVA	300
Secondary Volts	80 to 1000
Amps	4000 max.

3. Furnace roof with electrodes, fixed position.

4. Furnace crucibles, several sizes and shapes for smelting and melting. They are moved under the furnace roof as required.

5. Furnace ventilation system and gas scrubber.

6. Storage area for feed and supplies.

7. Furnace feeders.

8. Ladles and molds to receive the molten products.

9. Instrumentation.

10. Cooling water.

The hearth area of the furnace will be approximately 4 x 4 ft for a hearth power density of 20 kW/ft2.

The maximum smelting capability for sulphide concentrates will be 600 lbs/hr. The furnace will be operated in the batch mode for most of the time, which does not lead to a materials handling problem. Additional information regarding this initial project is provided in Appendix 2.

4.5 Future-In-House Projects

A number of potential future projects for the electric arc furnace and smelting facilities exist. They may be Ontario Hydro or customer sponsored projects. A few of the potential projects are listed below:

- Slag cleaning;
- Investigations into high voltage operation;
- Electrode studies;
- Melting of special alloys for the steel industry;
- Melting of precious metal scrap;
- Production of calcium cyanide;
- Recovery of precious metals from spent automotive catalysts.

The above suggests a need for experimental electrical furnace melting and smelting facilities. It is believed that the need for the use of these facilities will increase once they are in place. (See Appendix 2).

5.0 BUDGET

On the basis of information contained in 4.0 the following estimates can be given for the funding required to establish a Process Metallurgy Unit and R&D Program at OHRD.

5.1 Salaries for R&D Unit

Assuming three professionals and two technical support staff the total annual funding required to cover K rates expenses (salaries, overheads in 1987 $) will be:

3 x 80 K	$240 K
2 x 60 K	$120 K
	$360 K

With this funding the R&D unit will contribute man-hours to in-house projects, supervise contracted-out projects and provide consulting man hours to clients seeking expert advice on process metallurgy and related topics. It is assumed that part of this funding will be OHRD Metallurgical Research Department OM&A and part will be provided by transfer funds; relative proportions are yet to be negotiated.

Funding for the part-time Supervisor will be provided by Metallurgical Research Department OM&A and is included above.

5.2 Funding to Support Contracted-Out Projects

A number of potential contracted-out R&D projects have been identified in 4.3. It is suggested that $200 K is an appropriate level of funding to support R&D projects at Ontario industries. Again it is assumed that this will be made up of OHRD OM&A and transfer funds wit' relative proportions to be negotiated.

5.3 Funds For In-House R&D Program(s)

In addition to man-hour costs (already covered) there is a need to establish a facility to carry out R&D projects. The equipment recommended for the initial (and subsequent projects) is estimated to cost up to $500 K for the 250 kw furnace and ancillary equipment (see Appendix 2). This equipment would be located at the Lakeview Plasma R&D Facility.

The total funding required for the first operating year for a new process metallurgy research unit and program are thus:

K rate expenses (salaries, overhead)	$360 K
Funding of external research programs	$200 K
Research facility	$500 K
Total:	$1060 K

In subsequent years the funding would probably be in the order of $600-700 K.

6.0 SUMMARY

Visits to a number of Ontario-based metals producers have indicated that there are a number of R&D opportunities associated with current and future operation of these industries. It is strongly recommended that Ontario Hydro establish a Process Metallurgy R&D Program to provide technical assistance to these industries. The R&D Program should involve both in-house research and financial support of external research programs.

Through such an R&D Program Ontario Hydro can make a significant contribution to either maintaining or improving the competitiveness of these industries, thereby sustaining or creating jobs within the Province.

The in-house research will require a research facility. It is recommended that this facility be centered upon a flexible 250 kw electric furnace. The initial research project should involve an investigation into how a major metals producer in Ontario can optimize electric furnace operation and eliminate problems that are expected to arise as SO_2 emissions are reduced. Future research programs can also make extensive use of this facility.

The new research group that would be established at OHRD to carry out the in-house research projects can also act as consultants to Marketing Branch on a variety of process metallurgy topics.

Approved By:

J. Brown
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Metallurgical Research Dept

Prepared By:

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Engineer
Process Metallurgy Study

R. Bergman
Consultant
Process Metallurgy Study

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Divisional Projects Dept

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APPENDIX 1

TRIP REPORTS

Memorandum To DR. J. BROWN
Manager
Metallurgical Research Dept

Date April 10, 1986

Location or Dept

File 808.2715

Subject Visit to Falconbridge Re Materials Processing Study

On April 2, 1986, R. Bergman, R. Reesor and the author visited Falconbridge Nickel in Sudbury for discussions regarding our Materials Processing Study. We found a number of areas where R&D by OHRD or assistance from OH would be beneficial in terms of creating new electrical load or sustaining or improving current utilization of electrical energy in their nickel/copper smelting operation. A brief summary of these opportunity areas is as follows:

Changes to Smelting Process For Improved SO_2 Recovery

There are prospects for a research program right up to a pilot stage which involves reduction of SO_2 emissions and major changes to the mode of operation of the two 30 MW electric furnaces which are currently used for the bulk smelting of nickel and copper sulphide. Recently announced Provincial Government emission limits require Falconbridge to make process changes to reduce SO_2 emissions from 150,000 tonnes/year to 100,000 tonnes/year. Falconbridge already has considerable capital invested in SO_2 emission reduction* equipment and would logically like to achieve further reductions by making additional use of existing equipment.

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* In the 1970s Falconbridge modernized their complete smelter system at a total cost of close to $100M. Until the late 70s Falconbridge used a sinter strand and a blast furnace for their Ni/Cu smelting operation. Their plant had no SO_2 abatement equipment at all. In the late 70s their new smelter came on-line. It features a fluidized bed roaster and two 30 MW electric furnaces. Approximately, 75% of all sulphur entering the system is recovered in the form of SO_2 by treatment in the acid plant. The SO_2 recovery is from the roaster only, none is recovered from the convertor or the electric furnaces.

Falconbridge, understandably, is not happy that major government funding is being offered to competitors such as INCO to bring them up to the level of their current SO_2 recovery, which Falconbridge financed by itself in the 1970s.

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The best option for Falconbridge seems to be that of a "deeper roast" since they have good SO_2 recovery, which has some unused capacity, connected with the fluidized bed roasting system. By "deeper roasting they would drive off close to 65% of the sulphur compared to the current 58%. While deeper roasting is the most economical way to increase SO_2 recovery it presents a host of potential problems in the subsequent electric furnace operation. The problems are brought about by the change in system chemistry within the electric furnace. These include increased metal loss (Ni,Cu) to the slag, the build-up of an iron rich phase as a solid layer on the bottom of the furnace (because it has a higher melting temperature than the Cu, Ni matte). The potential research areas are thus:

- use of EM stirring to even out the temperature distribution in the electric furnace to prevent formation of the solid layer on the bottom of the furnace,

- development of remote temperature sensing equipment so that the solid layer could be detected and monitored,

- without something in the two areas above the solution is to increase the electric furnace temperature, giving greater Kwh/tonne matte, refractory wear problems, etc.,

- an additional area for research will be that of finding the optimum technique to recover the additional Ni and Cu lost to the slag, perhaps some electrically driven slag cleaning process can be developed.

Electrowinning of Ni and Cu

Since the initial operation of Falconbridge (1930) all final processing of the nickel/copper matte produced at Sudbury has been carried out in Norway with cheap hydroelectric energy through electro-deposition processes. There is an Ontario Statue which requires that this electrolytic processing being carried out within Ontario but every 10 years since 1929 Falconbridge has been granted an exemption and continued to carry out the electrowinning of Ni and Cu in Norway. The next date for renewal (or refusal) of the exemption is 1989 and Falconbridge staff are having another look at siting this part of the operation in Ontario. It was stated that electrical energy costs are marginally cheaper in Norway and labour costs are approximately the same as in Ontario. Falconbridge staff would earnestly like to see this electrowinning operation (100MW) moved to Ontario but there are two major obstacles.The first is the $300M investment required to construct an electrowinning facility in Ontario and the second is the question of what to do with the facility in Norway (a decision was just made, however, to invest $30M in the Norway operation to increase capacity by 30 M lb/year).

Falconbridge must make a presentation to the Ontario government in 1987 regarding a 1989 exemption. One factor which could help favour a new Ontario plant would be a new electrodeposition cell design which could reduce capital investment from $300M to $200M. Energy efficiency of the current cells is already quite good (>90%), any new cell would have to be aimed at increased power density to reduce size and capital cost. New current reversal techniques are one possibility for achieving increased power density. In summary, Falconbridge would welcome some OHRD effort in this area.

Other R&D Possibilities

Several other R&D possibilities were discussed. Briefly they are:

- plasma smelting of electrowinning cell sludge returned from Norway
- convertor heating via plasma torches
- ladle heating via plasma torches
- dust collection systems
- electric furnace slag cleaning for better metal recovery
- plasma melting of scrap (instead of induction) for input into convertors

DR. J. BROWN

April 10,1986

Summary

The visit to Falconbridge Nickel was very useful. Two major R&D opportunity areas exist. One involves SO_2 abatement and its impact on electric furnace operation, the second involves new cell design for electrowinning.

C.J. Simpson
Senior Research Engineer
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(Ext 122+6344)

R.A. Reesor
Engineer
Metallurgical Research Dept

R.A. Bergman
Consultant
Metallurgical Research Dept

Memorandum To DR. C.J. SIMPSON
Materials Processing

Date April 22,1986

Location or Dept KR187

File

Subject Visit to Kidd Creek Mines, April 16, 1986

Visit By:	Kidd Creek Staff:
C. Simpson	Leonard (Don) Sanderson, VP,Metallurgy
R. Reesor	Denis J. Kemp, Manager, R&D & Production
R. Bergman	John Mouland, Chief Eng, Hydromet & Electro-Chemistry, R&D Dept
	J. Doug Scott, Senior Staff Scientist.

SUMMARY

1.0 Kidd Creek Mines Ltd

The Kidd Creek Mines Limited Smelter and Refinery are located at Timmins, Ontario. It produces zinc and copper from ores mined locally. The zinc plant produces 130,000 MT/yuear of pure zinc and zinc alloys - in various cast forms. Copper is produced at a rate of 70,000 MT/vear in the form of cathodes.

1.1 Zinc Production

Two processes are used in the zinc plant for the recovery of zinc. In the conventional process, concentrates are roasted in fluid bed roasters. The sulphur dioxide is fixed as sulphuric acid; the calcine is leached in two stages to yield a zinc sulphate solution. A portion of the concentrate is treated by the Sherritt-Gordon pressure autoclave leach process to dissolve the zinc as sulphate, and to produce a discard residue. The solution is purified by zinc powder additions prior to electrowinning of zinc. Lead anodes containing 1.5% silver and aluminum mother plates (cathodes) are employed. The zinc cathodes are melted in induction furnaces, alloyed as required, and cast into various shapes. A total of 37 different alloys are produced.

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1.2 Copper Production

Copper concentrate is smelted by means of the Mitsubishi process to produce blister copper. The Mitsubishi process employs three furnaces in series. The concentrate is smelted in the first unit with oxygen enriched air. Slag and matte overflow to the second unit, the slag cleaning furnace. It is a three-electrode arc furnace. Coke is added to lower the copper content of the dump slag to below 0.7% copper. The matte from this furnace flows into the third furnace, in which the copper-iron-sulphide is converted to blister copper by oxidizing iron and sulphur with oxygen enriched air. The blister copper is further refined in anode furnaces and then cast into anodes. Copper cathodes are produced by electro refining the anodes in a tank house designed by Mitsubishi using a copper sulphate electrolyte.

1.3 Electrical Load

Total	175 MW	
Mine	25 MW	
Concentrator	25-30 MW	
Zinc Plant	60-65 MW	(50 MW for electrowinning)
Copper Smelter	28-30 MW	(12 MW for O_2 production 1500 MT/Day)
Copper Refinery	6 MW	

1.4 Sulphur Recovery

Kidd Creek recovers in excess of 98% of the sulphur contained in the concentrate as sulphuric acid. Total sulphur emission 9 MT/day.

2.0 AREAS OF POTENTIAL R&D ACTIVITIES

The following areas were suggested during the visit in which work done or sponsored by OHRD may improve the efficiency of present electrical power usage or lead to new applications of electrical power.

2.1 Zinc Electrowinning

The current efficiency of the zinc electrowinning plant is currently only 85%. This is in part due to the high current densities used in electrowinning and the electrolyte chemistry, and in part due to other factors which have not been identified.

Another area which merits investigation is the occasional strong bonding of zinc to the aluminum starting sheets.

2.2 Copper Electro Refining

It was noted that nodule growth on copper cathodes occurs only on one side of the deposit. It was postulated that this may be caused, at least in part, by induced magnetic fields. A magnetic survey would shed some light on the causes for nodule growth.

2.3 Casting of Zinc Ingots

Shrinkage cavities in large zinc ingots are overcome by "hot topping", eg heating the ingot tops with natural gas burners. It was suggested by Kidd Creek Limited that electrical heating of the ingot molds by induction heating would be preferred over the current gas heating practice.

2.4 Pumping of Molton Zinc

Pumps have been developed for molten lead and aluminum. According to Kidd Ceed there is a need for a molten zinc pump. Investigations into induction or magnetic pumps are of interest.

2.5 Pumping of Corrosive and Abrasive Solutions

Conventional pumps have an extremely short life under the very corrosive and abrasive conditions experienced in the Kidd Creek Mines operations. There is a need for a pump without moving parts, based on moving the solutions by electromotive or electromagnetic forces. Kidd Creek will supply OHRD with solution and slurry analyses.

2.6 Heating of Electrolytes

Electrolytes and process solutions are heated by means of heat exchangers or live steam injection. The former leads to scaling of the exchangers and the latter to water balance problems. A method for heating these solutions by inductive or microwave heating is of interest.

2.7 Descaling of Pipe Lines and Heat Exchanger

Scaling of pipes and heat exchangers in process metallurgy is a common problem. Removal of the build-up requires mechanical or chemical action.

Can techniques be developed which will prevent scales from forming or are there electrosonics or magnetic shock techniques which will permit ready removal of scales?

2.8 Plasma Application

Kidd Creek has a low grade Pb residue which contains 20-60 ounces/ton of silver. The possibility of treating this residue by plasma technology for the selective volatilization of lead over silver has been explored briefly. Further work is required to develop an economic treatment method.

2.9 Drying of Concentrate and Ore

An interest was expressed in reducing filter cake moisture from 12-18% H_2O to 6-8% H_2O and crusher plantfeed ore, -6", from 1-6 H_2O to 1-2% H_2O.

R.A. Bergman
Materials Processing
(Ext 122+7192)

RB:dr

Memorandum To	DR. C.J. SIMPSON Materials Processing	Date	May 12, 1986
Location or Dept	KR187	File	808.275 (T)
Subject	VISIT TO DOFASCO, APRIL 24, 1986		

B.A. Strathdee
C. Gladyz
J. Ashton
C.J. Simpson
R. Reesor
R.A. Bergman

SUMMARY

The Dofasco R&D centre was visited on April 24, 1986 to determine how OHRD can assist DOFASCO in increasing its profitability with particular emphasis on the use of electricity. Three potential areas were identified:

1. Assistance in commissioning of new R&D equipment and training of staff.

2. Induction heating of slab and strip edges to ensure uniform temperature distribution in the metal entering the rolling mills.

3. Assistance in the design of an induction heated hot metal mixer for hot metal superheating. Such a unit will increase the amount of scrap that can be processed by the B.O.F.

INTRODUCTION

Dofasco is an integrated steel producer with an annual capacity of 4.5 million tons of ingots and castings. Its main product lines are flat rolled products used by the automotive industry.

1.0 Energy Consumption: Dofasco is a large energy consumer at 70.0 x 10^{12} BTUs/year. Only 6.5% of this is consumed in the form of electrical energy. The blast furnace with its auxiliary equipment consumes about 70% of the total energy. The bulk of the remaining 30% are used in the soaking pits.

2.0 Product Qualities & Yield Improvements: Dofasco has made a $5 million expenditure on R&D equipment and committed $750 million over the next three years to improve product yield and quality to remain competitive.

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DR. C.J. SIMPSON May 12, 1986

Dofasco's technical emphasis has shifted from process improvement to product quality assurance and improvement. Some indication was given that Dofasco will be also moving into product development.

2.1 Laboratory Equipment: Dofasco has installed and partially commissioned new laboratory equipment. It was indicated that the staff is going through a learning period before full use can be made of the new instruments and techniques. This means a delay before full benefits can be derived from the new facilities. It is likely that Dofasco can benefit by interacting with experienced researchers from CHRD. This association could be of benefit to both companies.

2.2 Plant Improvement Program: The expenditure of $750 million is made primarily to improve the metal yield and the product quality. Dofasco is adding the following main items to their #2 Shop:

a) Concaster
b) Reheat furnaces (2)
c) Ladle Metallurgy System
d) New rolling mill stands
e) Extend the run-out table
f) Increase the number of down coilers.

After completion of this installation, approximately 50% of Dofasco's production will be concast steel.

The ladle furnace permits raising the steel temperature to its optimum value for continuous casting. It is also capable of vacuum refining heats. Three hundred MT ladles are railed under the ladle station. The metal is heated by 3 electrodes, the electrical system is rated at 46 MW and capable of heating the steel at a rate of $5^{o}C$/min upto $100^{o}C$. Gas injected through porous plugs stirs the melt.

Slab and strip edges, cool preferentially during handling. To assure a uniform product quality during rolling temperature distribution through the steel must be even. Current practice is to reheat the steel in reheat furnaces. Some work has been done in Japan on heating the cold edges selectively by gas burners to allow direct rolling instead of the reheating process of 350 MT of slabs/hr. Interest was expressed by Dofasco in induction heating of slab or strip edges during processing of the metal.

3.0 Long-Term Plans

3.1 Dofasco has no plans to increase either their iron or coke making capacity.

3.2 They plan to increase the usage of scrap through coal injection into the B.O.F. and by increasing the iron temperature by using mixers equipped with channel induction heaters. Such an installation exists in South Africa. The mixers have a capacity of 1000-2000 MT.

3.3 Increase in the hot blast temperature from 1800 to 2200°F (980-1200°C) by rebuilding the hot stoves.

3.4 Drying of the blast air.

3.5 Increased oil, gas, and in particular, coal injection through the blast furnace tuyeres. The coke ovens are only capable of supplying 80% of the fuel needs; they are in good condition. No rebuilding is required, but conversion from wet to dry core quenching is being considered to avoid heat losses through steam generation and emission of noxious gases.

3.6 Use of fluxed pellets which will permit an increase in the blast furnace stack temperature from 2800°F(1538°C) to 3500°F (1927°C). This results in a higher furnace productivity.

Potential Item for Cooperation:

An increase in the hot iron temperature by 100°C will increase the amount of scrap that can be charged to the B.O.Fs by about 5%, or from 30 to 35%. Although this is a small relative increase, it represents a large cost savings. Electrical heating of the hot metal in a mixing vessel is less costly than superheating the metal in the blast furnace. The total hot metal cost is $180/MT. If scrap can be purchased for $100/MT the energy value of the metal is $80/MT.

It was suggested that OHRD assist Dofasco in the preparation of a proposal for a hot metal mixer equipped with induction heaters, with the leg work to be done by OHRD.

4.0 Application of Plasma Technology

Dofasco has looked at plasma applications for air preheating, drying of concentrates, direct reduction, and as a supplemental heat source for the hot blast. None of the applications is economically viable. They keep an observed status only.

DR. C.J. SIMPSON May 12, 1986

5.0 General

5.1 R&D staff - 75

5.2 Electrchemical work is minimal. Only electro-tinning and chrome plating of tin free steels is carried out.

5.3 Dofasco does not develop technology. They buy and adapt.

5.4 Approximtely 30% of steel produced in the US is made in electric furnaces.

Prepared By:

for

R.A. Bergman
Materials Processing
(Ext 122+7192)

/dr

Memorandum To DR. C.J. SIMPSON
Senior Research Engineer
Divisional Projects

Date May 29, 1986

Location or Dept KR187

File 808.274(T)

Subject Visit by Pamour Porcupine Mines Ltd on Magnesite Deposit Utilization

Date: May 23, 1986
Location: OHRD

Present: Ron Sweetin, Charles Gryba, C. Simpson, R. Reesor, F. Chu, R. Bergman

Purpose of Meeting: Explore the possibility of how OHRD can assist Pamour to recover magnesium from magnesite using Plasma Technology.

Pamour owns a magnesite deposit south of Timmins. The size of this deposit is estimated at 50 to 300 million tons. The ore contains primarily: Quartz, talc, magnesite and iron oxides. The Mg content of the run of mine ore is 22% Mg. An 85-90% $MgCO_3$ concentrate can be obtained from the ore by flotation techniques. The particle size of the concentrate is 70 - 100 mesh.

Pamour has looked at various routes for exploiting the deposit, including the production of $MgCl_2$, MgO and a separate talc product. They have also explored the conventional magnesium metal production methods. They were rejected, primarily because of the high energy requirement at 12,000-20,000 Kwh/ton of magnesium and the corrosive nature of the chloride system.

To make exploitation of the deposit economically attractive, a mining rate of 25,000 to 50,000 tons/year is required. A 200 Tpd mill is available for the production of small market evaluation samples of magnesite and talc.

Pamour's main interest lies in the development of a magnesium metal production process based on plasma technology. The following action was agreed on:

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DR. C.J. SIMPSON May 29, 1986

1. Pamour will supply OHRD with 4 lb samples each of magnesite concentrate and MgO produced from it by calcining. The material will be screened on -100 + 325 mesh. Chemical analysis of the product will be supplied. ACTION by: Pamour.

2. OHRD will run the samples through the 80 KW plasma arc.

2.1 Magnesite: to determine if it can be decomposed by the plasma arc.

2.2 A mixture of MgO and carbon: to determine if Mg metal can be produced. The exit product from the plasma furnace will be analysed by spectroscopy for the presence of metallic Mg. ACTION by: F. Chu.

3. A theoretical assessment of the reduction of MgO by C by a plasma reactor will be carried out to determine the chemical viability and energy requirement of this approach. It is proposed to quench the Mg metal in an aluminum splash cooler to produce a Mg-Al alloy. ACTION by: R.A. Bergman.

R.A. Bergman
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(Ext 122+7192)

/dr

Memorandum To DR.C.J.SIMPSON
Senior Research Engineer
Divisional Projects Dept

Date June 9, 1986

Location or Dept KR187

File 808.274(T)

Subject Visit Report to Eldorado Resources Ltd

Date of Visit: May 26, 1986

Location: R&D Laboratories, Ottawa

Contacts

Dr. Irwin Itzovitch	Manager, Research & Business Development
Dr Andrew J. Oliver	Head, Hydrometallurgy, R&D
Mr. R.J. McClure	Head, Pyrometallurgy, R&D
Dr. T.W. Zawidzki	Head, Special Projects, R&D

Visit made by:

Dr. C.J. Simpson
Mr. R. Reesor
Mr. R.A. Bergman

Purpose of the Visit

Explore areas where direct or indirect involvement by OHRD in R&D projects may promote the use of electrical energy.

Summary

Four potential areas were identified in which OHRD may contribute to the R&D efforts of Eldorado Resources Ltd:

1) The application of auxiliary microwave heating to uranylnitrate decomposition pots to increase their capacity.

2) Processing of magnesium fluoride for the removal of residual uranium to produce a product that can be either dumped or recycled.

3) Assistance in Plasma technology in the decomposition of UF_4 and UF_6 to produce the metal directly. OHRD has assisted Eldorado in the past, but more help is required.

4) Optimization of the magnetic properties of the neodymium-boron-iron permanent magnetic alloy.

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DR. C.J. SIMPSON June 9, 1986

1. The Company: Eldorado Resources Ltd, the major operating subsidiary of Eldorado Nuclear Ltd, has three divisions - Eldor Mines operates the uranium properties and mill in the Rabbit Lake region of Northern Saskatchewan; Fuel Services operate a uranium refinery at Blind River, Ontario and uranium conversion plants at Port Hope, Ontario; Specialty Metals produces uranium metal and metal alloys, also at Port Hope. The administrative services and R&D support are also part of this division, but located in Ottawa.

A second subsidiary, Eldor Resources Ltd, owns one-sixth interest in the Key Lake Mine and related properties in Northern Saskatchewan.

1.1 Mines: Elliot Lake is the lowest grade mine at approximately 1.8 lbs of U_3O_8 per ton of ore. The mines at Saskatchewan are much higher grade at more than 20 lbs of U_3O_8/ton of ore. Since mining and milling costs have a major effect on the product cost, it is likely that Elliot Lake could be shut down in the near future and that Eldorado would draw all its concentrates from the Saskatchewan operation.

1.2 Refinery: The yellow cake U_3O_8, which is produced at the mine-mill site, is shipped to Blind River, Ontario, where it is refined to UO_3. U_3O_8 is first converted to uranyl nitrate ($UO_2(NO_3)_2$) which in turn is purified by solvent extraction and then decomposed thermally to UO_3 powder for shipment to Port Hope.

1.3 Conversion: In Port Hope, UO_3 is converted into three major products, namely uranium hexafluoride (UF_6) for the enrichment market (approximately 80% of product), uranium oxide pellets (UO_2) for the CANDU reactor and uranium metal.

Eldorado carries out conversions not only on their own materials, but also on a custom basis. The capacity of the UF_6 plant is 9000 MT/year and the UO_2 plant 2800 MT/year of U as UO_2. The capacity for uranium metals is not quoted.

2. R&D Facilities

The R&D group has a staff of 47 (18 professionals, 23 technical) with an operating budget of $3 million and a capital budget of $0.2 to 0.5 million per year.

It has three major responsibilities, which are roughly evenly distributed:

- Direct technology assistance to the operating plants;

- Process improvements and cost reductions in existing plants;

DR. C.J. SIMPSON June 9, 1986

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It has three major responsibilities, which are roughly evenly distributed:

- Direct technology assistance to the operating plants;

- Process improvements and cost reductions in existing plants;

- Development of new processes for existing business and development of new business ventures based on Eldorado technology, but not related to uranium.

Irwin Itzkovitch has been seconded from the R&D group to push the new business development interests of the company. The main target at present is the scale up and commercialization of a Neodymium-Boron permanent magnet (Nd - 29%; B - 1%; Fe - 70%). This process is based on the conversion of neodymium oxide to the fluoride followed by magnesium reduction to the metallic state.

It is expected that the plant will be sited at Port Hope and may create as many as 25 new jobs.

3. Areas in which Eldorado's and OHRD interests may coincide

3.1 Decomposition of Uranylnitrate to UO_3: Uranylnitrate is decomposed to UO_3 in twelve 4' diameter stainless steel pots. The capacity of each pot is 1,000 Tpy for a total of 12,000 Tpy. Eldorado is investigating the possibility of increasing their capacity. This can be done either by increasing the number of pots or by introducing more energy into the pots.

The pots are fitted with impellers which closely match the hemispherical pot bottom. Heat is supplied to each pot by 200 KW electrical heaters. The outer skin temperature of the pot is limited to 570°C. A crust of material builds up inside the pot which limits the heat transfer rate and hence the productivity of the pot. Materials of construction of the pot limit the outside pot temperature. Therefore, another way must be found to drive heat into the reaction pot. Eldorado wishes to explore the possibility of using microwave heating. This requires assistance by a knowledgeable group such as OHRD.

3.2 Processing of MgF_2: Uranium fluoride is reduced to the metal according to: $UF_4 + 2\ Mg = 2\ MgF_2 + U$. The resultant magnesium fluoride contains approximately 5% uranium metal in the form of fine prills. It cannot be dumped unless the uranium concentration can be brought down to <50 ppm. Eldorado has an accumulation of several million lbs which have to be stored. Interest was expressed in finding a solution to this problem.

DR. C.J. SIMPSON June 9, 1986

4. Plasma Technology

Eldorado is exploring the possibility of producing uranium metal directly from UF_4 or UF_6 using plasma technology. They claim to have had moderate success in this program. Their knowledge in plasma technology is very limited and they could therefore use some assistance from OHRD.

They appreciate the help OHRD has given them in the past.

5. Neodymium Permanent Magnetics

Eldorado are quite confident that they can handle the processing part of the project, but they may not be fully equipped to optimize the magnetic properties of the alloy since they do not have the background in 'magnetics'. This is another area where OHRD could be of assistance.

R.A. Bergman
Materials Processing
(Ext 122+7192)

/dr

Memorandum To DR. J. BROWN
Manager
Metallurgical Research Dept

Location or Dept KR282

Date June 13,1986

File 808.274(T)

Subject Visit to Atlas Alloys

On May 9, 1986 R. Bergman, R. Reesor and the author visited Atlas Alloys in Welland for discussions on process metallurgy R&D opportunities. The visit was hosted by Mr. J. Thompson, Dr. D. Whittaker and Mr. B. Carson. The important points of the discussions are summarized below:

Modernization of Atlas Alloys Operation:

J. Thompson gave considerable information relating to the future plans of Atlas Alloys. Their main product at Welland is a variety of stainless alloy barstock. A developing market and product is HSLA barstock which Atlas hopes to see grow for automotive applications. The annual combined production of stainless barstock and HSLA steel barstock is 175 K tonnes. All stainless sheet is produced at the Atlas plant in Quebec.

Atlas Alloys is currently planning significant changes to the Welland operation. The news is both good and bad for Ontario Hydro. The changes are mainly motivated by the need to produce a higher quality product just to keep abreast of competition. Reduced operating costs are also a goal.

The following changes are planned and should be implemented within three years:

1) Production levels are to be kept at the same level but this will be accomplished in one furnace rather than the two 60-tonne furnaces now in operation. The capacity of the furnace remaining in operation will be increased to ≈ 70 tonnes. Throughput of this furnace will be effectively doubled through the increase to 70 tonnes and by decreasing transformers may be required. The latter will be accomplished through use of oxy/fuel burners (as at Lasco). The electrical energy use per tonne will be decreased from ≈ 540 kWh/tonne to ≈ 480-490 kWh/tonne. Scrap preheating from hot off gases, will also contribute to this energy reduction. Upgrading of the 30 MVA transformers may be required.

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2) Other technology changes, which will improve quality, are bottom tapping, foamy slag practice, supplemental O_2 injection.

3) Ladle refining, using argon bubbling, which is already an advanced practice at Atlas, will continue with minor improvements. No electric heating of the ladle is needed now or in the future. The melting furnace will be used to provide enough superheat.

4) Continuous casting will also be added. Atlas sees this as a necessity to stay in business. No electric heating is seen to be necessary for controlling melt temperature in the caster, however.

With these changes Atlas will have upgraded their melting and casting to match the advanced technology they already have in their refining operation.

In a slightly longer time frame (≤5 years) Atlas plans to build a new rolling and finishing mill. This will be largely prompted by the physical separation between the new caster and the current rolling and finishing mill which would necessitate excessive reheating. Reheating is currently done in 17 gas-fired soaking pits. In the future operation reheating will be via induction directly after the caster but less reheating will be required since the billet product coming from the caster will still be at a very elevated temperature. The new induction heating load should replace some of that lost to oxy/fuel burners and energy recovery through scrap preheating.

R&D Opportunities

Atlas Alloys has a policy of purchasing rather than developing technology. Atlas will be dealing with either Krupp or BSE of Germany for plant modifications which will be turnkey contracts with built-in production guarantees. There are no R&D opportunities for OHRD which would be of interest to Atlas. They will continue to keep abreast of new technology through annual visits to Europe and Japan. They will continue to watch developments in DC furnaces and plasma furnaces for possible technology replacement in the late 90's. They are also very interested in the Tibur/Howden PEAR Project since they believe they will have to process bag house dust by 1990. Their current dust generation is 1500 to 2000 tonnes/year. Another area of interest is reduction in electric consumption which contributes significantly to the production cost. Since this is common to all electric furnace operators it could be the basis of a general R&D program.

DR. C.J. SIMPSON June 13, 1986

Recommendations

The only justifiable OH activities in the immediate future in relation to Atlas are marketing activities.

Interactions with Krupp and/or BSE (see attached business card) regarding use of oxy/fuel burners are recommended. Discussions on use of plasma torches rather than oxy/fuel burners should be initiated. German consultants may be more interested in the oxy/fuel option because of European practice which is probably influenced by the higher cost of electrical energy in Europe.

Discussions relevant to the induction reheating planned for the new rolling mill could also be initiated.

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/dr

Memorandum To: DR. C.J. SIMPSON
Senior Research Engineer
Divisional Projects Dept
KR187

Date: July 2, 1986

Location or Dept

File: 808.274(T)

Subject: Visit to Algoma Steel Corporation Ltd, Sault Ste Marie, Ontario

R. Reesor
R. Bergman

G. (Gary) Lucenti, VP, Operations (absent)
W. (Bill) Suhay, Superintendent, Operations Technolog
Len Dupuis, Manager - Engineering
Walter Uhl, Senior Project Supervisor
Bruce Edwards, Superintendent, Blast Furnace.

The Algoma Steel Corporation Ltd, Sault Ste Marie was visited on June 20, 1986 for discussions on process metallurgy R&D opportunities.

Bill Suhay gave a brief outline of the Algoma Steel Corporation's operations, which was followed by discussions on process metallurgy R&D opportunities and a tour of the blast furnace operation guided by Bruce Edwards.

The Company

Algoma Steel is under severe economic pressure as a result of shrinking markets for steel, in particular markets for pipe and structural steel. The current work force of 9500 will be reduced to 8000 in the fall.

The Algoma Steel Corp is a fully integrated steel plant with its own iron ore and coal mines. Coke ovens and a sinter plant are located at the plant site. Of the four blast furnaces available, two are presently in operation. The smaller furnace has a capacity of 2500-3000 Tpd of hot metal, whereas the larger and newest furnace has a nominal capacity of 5000 Tpd but has been operated at up to 6000 Tpd at a top pressure of 20 psig.

The blast furnace feed is a mixture of pellets, 60%, from the Wawa Mine analysing 65% Fe and sinter, 40%, analysing 45-48% Fe. The coke rate is 1000-1200 lbs per ton of hot metal. Fuel injection (tar or oil) capabilities exist, but are not utilized at present.

A slag granulation plant is under construction and scheduled to commence operation in August 1986.

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Hot metal from the blast furnaces is transferred to the BOF's in 250 ton torpedo cars. The hot metal is desulphurized in these cars by calcium carbide injection.

The plant has two BOF shops:

#1 BOF Shop:

- Three 100-ton vessels.
- Total production 500,000 Tpy (capacity 600,000 Tpy)
- Continuous casters - 450,000 Tpy
  One 4 strand, bloom
  One 2 strand, bloom
- Ingots - 50,000 Tpy
- Products: Seamless tube 1/3
  Rail 1/3
  Structural 1/3

#2 BOF Shop:

- Two 250-ton vessels.
- Total capacity 2.5 million Tpy
- Continuous caster - capacity 1.4 million Tpy
  2 strand slab caster
- Ingots - 950,000 Tpy
- Products: Sheet 2/3
  Plate 1/3

R&D at Algoma:

Algoma does not have central research facilities. Plant investigations and improvements are carried out by a group of 30 engineers and support staff. Algoma relies heavily on purchased technology.

R&D OPPORTUNITIES

1. Electromagnetic Stirring of Continuous Caster Molds: Magnetic stirring of CC molds is promoted by NKK of Japan, whereas the European operators do not see any benefit in employing this technique. NKK claims that magnetic stirring prevents bridging in the mold, whereas the Europeans claim that it causes defects in the product.

Algoma is looking for assistance in resolving the question whether or not magnetic stirring is beneficial to their operation.

2. Shell Temperature Control in Seamless Tube Production: During the production of seamless tube, the outside of the shell cools more rapidly than the inside, resulting in temperature difference trials between the outside and inside of 50°F. This temperature differential results in an uneven wall thickness along the tube. Algoma is looking for a method of overcoming this problem. Only a brief examination of induction heating has been made in the past. The following operating conditions were given:

Shell diameter	8 - 16"
Shell thickness	3/8 - 1"
Travel speed	1000 ft/min
Temperature	1800-1900°F.

3. Temperature Measurement: An accurate and reliable temperature measurement of the steel on the run-out table prior to coiling is essential for obtaining the desired metal properties. So far it has not been possible to carry out this temperature measurement reliably. This is in part due to unsatisfactory hardware and also due to the difficult operating conditions, eg water is sprayed on the steel surface to cool the metal.

Algoma expressed an interest in obtaining assistance in improving the steel cooling process including the development or adaptation of reliable temperature measurement methods. The possibility of model studies was also mentioned.

4. Ladle Degassing: Steel is degassed at a pressure of 0.05 mm. Steam ejectors are normally used to create this underpressure. Vacuum pumps and water ejectors or a combination can be used.

Algoma's interest lies in finding the most economical system for obtaining these low pressures.

5. Gas Stirring & Injection: Another method employed for degassing and metal stirring is by introducing gases through a porous plug into the liquid metal. Depending on the grade of steel argon, or nitrogen followed by an argon rinse is used. Recently CO_2 has been used as a stirring gas in an effort to reduce the cost of gas. Algoma is interested in obtaining information on gas stirring with CO_2 and the combination of magnetic and gas stirring in an ASEA type refining ladle furnace.

6. Production of Process Gases: The high cost of industrial gases is of concern to Algoma. Their annual cost for argon gas alone is $1 million. They are interested in finding ways to improving the electrical efficiency of the cryogenic gas separation methods for N_2, O_2 and Ar, and also alternative methods for producing them.

DR. C.J. SIMPSON July 2, 1986

General

The Algoma Steel Corp is under severe pressure to reduce their costs; the main focus of the people talked to is on short term gains with little time devoted to longer term objectives. This is understandable in the light of the severe economic pressures under which the company operates.

At the end of the meeting we were asked to let Algoma know what the outcome of the current study is. When a decision has been reached, Algoma would like to know what kind of support, if any, can Algoma expect from Ontario Hydro.

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/dr

Ontario Hydr

Memorandum To: DR. C.J. SIMPSON
Senior Research Engineer

Date: July 24, 1986

Location or Dept: Divisional Projects Dept
KT.187

File: 808.274 (1)

Subject: Visit to Chromasco Limited
Haley, Ontario

C.J. Simpson
R.A. Bergman
R.A. Reesor
G. Brown, Eastern Region

D. Zuliani, Director of Research & Development
A. Froats, Chief Metallurgist

On July 22, 1986, Chromasco Ltd was visited for two reasons:

1) For general discussions on process metallurgy R&D opportunities in Chromasco's operation.

2) To discover Chromasco's rationale for converting their electric retorts to natural gas.

Doug Zuliani gave a brief outline of Chromasco's operation, the "Pidgeon Process". This was followed by a discussion about their facilities with respect to R&D opportunities, and then a tour of the reduction furnaces and metal melting shop.

Chromasco Operation

Chromasco Ltd is using the basic flowsheet of the well-established Pidgeon Process (Appendix A, page 584). The dolomite ore is mined on site. The ore is then calcined in a gas kiln at 1300 - 1400°C. The calcined dolomite powder is then pulverized and mixed with ferrosilicon (from their operation in Quebec). The charge is then heated up to, and then held in vacuum at 1200°C for an 8 hour cycle. The Mg metal is condensed on a water-cooled sleeve insert. These condensed Mg crystals are removed and melted in gas-fired pots (5000 lb batches) with a diluted SF_6 covering. The melt is then cast into ingots, billets or granulated.

Chromasco's retort capacity is about 11,000 tonne/yr based on a 3 x 8 hour/day operation. The products consist of 9000 tonne/year of Mg, 900 tonne/year of Ca, and 150 tonne/year of Sr. There is a new plant planned near Pembrooke to isolate their Sr production and to allow them to optimize their production of Mg. Chromasco is planning to use gas-fired retorts in this expansion.

Chromasco considers that the advantage of their silicothermic process over electrolytic production routes is their ability to produce a higher quality product. Chromasco is leaning their efforts towards high purity products, ie. Mg for alloys in automotive castings. Chromasco is also hoping that the market for Sr will grow substantially in the future and they are actively looking for new Sr applications. They are sponsoring university research with respect to this area.

Natural Gas vs Electric Retorts

The reduction process presently takes place in:

8 electric furnaces (@ 960 kVA, SiC glow bars)
- 8 x 40 retorts

8 gas fired furnaces (either having 24 retorts or 40 retorts)

Chromasco has found the recoveries in the electric and gas-fired retorts are approximately the same (~ 85%). It was estimated that the energy efficiency of the electric furnaces was about 30 - 40% and the gas furnaces were 25 - 30% (based on the energy units input per lb of metal output).

The high alloy (Ni, Cr) retorts have about 15% longer life expectancy in the gas furnaces compared to the electric furnaces (210 days vs 180 days). This early failure in the electric furnace is caused by poor distribution of the heat from the electric glowbars creating hot spots on the retorts. Due t the turbulent heating inherent of natural gas burners, there is a much more uniform heat distribution in the gas-fired furnace.

Since the cost of the retorts represents about 2/3 as much as the energy costs in the overall production cost, the 15% longer retort life was not a major factor in the decision to convert to gas-fired furnaces.

Chromasco outlined their estimated cost savings by changing to natural gas, listed below:

The existing natural gas furnaces have a 2-3 ¢ /kg of Mg advantage over the electrical furnaces

Their newly negotiated natural gas contract will provide an additional 6 ¢ /kg advantage to natural gas

Their planned purchase of waste gas heat recuperators should give the new natural gas fired furnaces an additional 13 ¢ /kg advantage over the existing electrical furnaces.

Chromasco has estimated that this capital investment to convert to natural gas will return a 22 ¢ /kg savings over the existing electric furnaces.

Chromasco's present electrical energy cost averages $.0319/kwh.

R&D Opportunities

1. Chromasco has looked at increasing their present production capacity. The retorts of the gas fired kilns are 2 ft longer, therefore allowing each retort to reduce 25% more charge than the electric furnace retorts. Chromasco has looked at increasing the length of the electric retorts, but they foresee several problems:

   The length of the necessary glowbar would cause problems in that a higher quality glowbar would be required in order for it to sustain its own weight.

   This longer glowbar would have a higher resistance which means a higher voltage would be required to maintain the present temperatures. The existing transformers are operating at their limits already. Changes in the electric requirements for the glowbars would translate problems through the entire in-house electric supply.

   Chromasco did not appear interested in pursuing approaches for increasing their capacity and maintaining electrically heated retorts.

DR. C.J. SIMPSON July 24, 1986

2. Chromasco is actively investigating the purchase of an induction furnace capable of melting materials from Mg up to steel. They are interested in something in the 100 kW range and asked for some assistance in making an appropriate choice. The furnace is most likely to explore an alternative for their present gas-fired metal melting pots and for new alloy development.

3. Chromasco is also very interested in looking at ways to increase the heat transfer in the retorts (ie. through the vacuum to the charge). This may even involve a new retort design. The purpose would be to lower the cycle time (8 hours) and maintain the recovery. A small decrease in the cycle time would mean a substantial savings in the unit production costs.

   One suggested technique involved developing a technique for preheating the charge and therefore achieving the reaction temperature much faster. Several preheating alternatives were discussed; electric heating would most likely be involved (ie. a resistance heated expanded mesh).

4. Although Chromasco's 85% recovery is acceptable, they are interested in changes which could enhance this figure.

SUMMARY

Chromasco indicated they are presently committed to the future conversion of their electric furnaces to natural gas. They did not appear to have investigated many approaches to optimize their present electric furnaces.

At the close of the meeting, we were asked to let Chromasco know the outcome of our report.

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RR/lct

Ontario Hydro

Memorandum To DR. C.J. SIMPSON
Senior Research Engineer
Divisional Projects Dept

Location or Dept KR185

Date July 30, 1986

File 808.274(T)

Subject Visit to Fahramet Foundry
Orillia, Ontario

R. Bergman
J. MacLaughlin
R. Reesor

C. Steel, Manager, Metallurgical R&D
G. Jacox, Vice-President

On July 16, 1986, a visit was made to Fahramet in Orillia. This foundary produces a broad array of castings. Their product line includes 250-300 different castings which are produced in one of three ways: centrifugal casting, shell molding or sand molding. The end-users of these products include many different industries (ie. petrochemical, mining, forestry, metallurgical, automotive, etc).

Fahramet's Operation

Fahramet uses very high quality raw materials. It was estimated that 90% virgin materials are used. Fahramet purchases only very high quality scrap from reliable sources (ie. scrap retort tubing from Chromasco) where the composition can be guaranteed.

Fahramet's strict adherence to the use of only high grade scrap is to avoid the pick-up of tramp elements (ie. Cu, Pb, As, etc) which can be devastating to the quality and properties of the castings. Fahramet also has very limited capabilities for slag cleaning operations.

Fahramet uses 4 small (up to 2.5 tonnes) arc furnaces and 4 small induction heated furnaces. The induction furnaces are used mainly for the centrifugal casting where the arc furnaces are used in the shell and sand casting operations. There is also a lot of preheating with natural gas for the centrifugal mold shells, ladles etc.

The research capabilities of Fahramet are rather limited. Most of the research carried out is in assisting the sales personnel on detecting sources of customer complaints. There is very little research done on process improvement technologies.

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DR. C.J. SIMPSON July 30, 1986

AREAS OF INTEREST

1) Fahramet is experiencing a problem with slag forming in their induction furnaces and no means to remove it. This is causing an unacceptable number of defects in the centrifugal casting operations. Fahramet is interested in some means of skimming this slag layer before pouring.

2) Fahramet is looking for better pouring techniques in the sand casting operation in order to lower the gas uptake by the metal upon pouring into the risers. Techniques for lowering the turbulence during pouring would solve this problem since less surface area would be exposed to oxygen and there would be less mold erosion.

3) Fahramet is experimenting with the use of ceramic filters for inclusion removal from the molten metal during pouring. They have been unsuccessful to this point mainly due to the problem of slag being present in the induction furnaces. Due to the chemistry and viscosity of the slag, it reacts with the filters and plugs the holes. To attempt to avoid these problems, Fahramet is looking at the feasibility of changing to bottom pouring practices.

4) Fahramet is presently reclaiming about 60% of their casting sand using only screens. One may look at the feasibility of a thermal reclamation process.

5) Fahramet are storing a large number of barrels of oil contaminated high alloy turnings from their machine shop. They cannot be used in the present state and scrap dealers are offering next to nothing for them. This could be one application for the plasma facility at Lakeview; a small pilot melting furnace for high alloy scrap.

Fahramet, like many companies, have several ideas on process improvements but they have very limited people or resources to fully investigate them.

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Ontario Hyd

Memorandum To DR. C.J. SIMPSON
Senior Research Engineer
Divisional Projects Dept

Date August 21, 1986

Location or Dept KK187

File 808.274(T)

Subject Visit to Stelco Research Centre, Burlington, Ontario

Mr. R. Bergman
Mr. R. Reesor

Mr. Nick Danielack
Mr. Don George,
Research Manager
Mr. Roy Littlewood,
Senior Tech. Advisor

On August 12, 1986 Mr. R. Bergman and the author visited Stelco's Research Centre for discussions on process metallurgy R&D opportunities in the steel industry.

R&D at Stelco

Stelco does have a central research facility in Burlington. Stelco purchases turn-key technologies when they see fit and the research centre will assist in the commissioning and process optimization stages. The research centre also assists in the evaluation and selection of new technologies. There is no pilot scale t t work carried out on a technology before it is installed but, subsequent to the commissioning, a lot of process modelling is done to optimize the operating parameters.

There is an increasing effort within Stelco to produce products which meet their customers strict quality requirements (service their customers). This has a direct effect on the type of research being carried out.

R&D Opportunities

General

It was emphasized very strongly that due to the limited personnel and resources at Stelco research (common with most Process Metallurgy companies), there is a major weakness in research in basic sciences. They felt this was especially evident in the area of arc physics, plasma physics, operation of d.c. arc furnaces, optimal electrode configuration on arc furnaces, etc. It was suggested that Ontario Hydro could make a valuable contribution to the industry by

conducting and/or supporting research on the fundamentals of electrotechnologies and understanding the implications of their application to the steel industry.

Stelco has great expertise in the chemical and metallurgical processing aspects of making steel but they have great trouble understanding or solving problems relating to basis arc physics, plasma characteristics, phase alignment, etc. Stelco admitted a major weakness is their blind spot with respect to the theory of electrotechnologies; Stelco accepts technology as it is recommended by the supplier with very little in-house input into modifications. Assistance by Ontario Hydro in this area would be valuable.

Specific Areas

1. Stelco is very much interested in the use of electro-magnetic containment of liquid metal to reduce the contamination from erosion of refractory materials as well as to obtain a more uniform metal flow through the refractory nozzle.

2. In the past some work was done with the University of Toronto on the use of linear induction motors to transport hot materials. There is still an interest in this area.

3. Accurate control during the cooling of strip products is a problem. The strip is moving at ≈2000 ft/min and the control of the cooling cycle determines the properties of the finished strip. With respect to the same problem, Stelco is interested in techniques of moving steel strip without metal to metal contact.

4. The heating of billets for temperature homogenizing using resistance or induction furnaces was also of interest, particularily the use of induction coils for edge heating of strip, billets, etc.

5. A concern for Stelco at the present time is the feasibility of using of an auxiliary heat source for the tundish (ie. plasma or induction). The purpose of the heat source being, to reduce the degree of superheat presently required in the ladle. During the continuous casting campaign the hot metal heat loss is about 1.5 - 3.0 °C/min. The casting temperature can easily vary 100°C from the start to the end of the casting cycle. This causes casting control problems. Auxiliary heating of the tundish will also allow the hot metal to be delivered to the ladle furnaces at

lower temperatures, thereby increasing productivity. Although there are several advantages of heating the tundish, the primary objective is to maintain a constant pouring temperature during continuous casting.

6. Stelco is interested in advances in the use of lasers for measurement purposes as well as high powered processing applications. Stelco is using lasers for the measurement of their BOF refractory wear. There is also an interest in using high powered lasers for welding pipes and tubes or joining large sheets together. Stelco has very limited capability to look at metallurgical processing applications of lasers. Stelco has briefly looked at using lasers as a measuring device, for controlling gauge tolerances in the hot rolling operations; there are problems in maintaining the flatness of the rolled sheet steels.

7. Stelco also experienced problems with accurate high and low temperature measurements. There are problems getting consistent temperature readings of the internal product. There is a tendency to get readings from the billet surface or scale which obviously differs greatly from the body temperature.

8. The use of laser spectroscopy for the on-line analysis of molten metal is of interest. There is some work being done in this area at Los Alamos in New Mexico, and Stelco sees this as an important development for increasing productivity and quality in the steel industry.

9. Stelco is also carrying out research on the chemistry of electro-galvanizing and -plating of zinc, and chrome plating for tin-free steel.

10. Slag chemistry modifications are part of Stelco's ongoing research especially the use of foamy slag practices and characteristics.

Future Plans

Stelco outlined their plans for the installation of a 120 ton single electrode ladle arc furnace (ASEA) at their Hilton Works by September 1987 and a 230 tonne unit at the Erie Works by 1988. Stelco suggested they would be interested in utilizing the proposed electric arc furnace at Lakeview in order to optimize the operating parameters in these ladle furnaces (ie. degassing, alloying, slag chemistry, etc).

DR. C.J. SIMPSON August 18, 1986

Stelco also emphasized that more research must be carried out on the operation of a tundish heating device but, they are strongly considering this technology for the future because temperature variation during continuous casting is a major problem.

A short visit was also made to Mr. Les McLean at the Stelco Tower (V.P. - Quality and Technology). Mr. McLean expressed his support of Ontario Hydro's initiative. It was suggested OHRD should initially focus on one area of expertise (ie. electric arc furnaces and industrial plasma applications).

At the end of the meeting we were asked to let Stelco know the outcome of the current study.

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APPENDIX 2

ESTABLISHMENT OF AN ELECTRIC FURNACE RESEARCH FACILITY AT ONTARIO HYDRO RESEARCH DIVISION

SUMMARY

The plans for the installation of an electric arc furnace pilot plant by Ontario Hydro were discussed in some detail during a meeting held between Mr. R. Bergman and Dr. G.H. Kaiura on August 8, 1986 at Falconbridge, Ontario. Particular emphasis was placed on the testwork requirements as seen by Falconbridge Limited. Falconbridge is examining methods for overcoming the build up of metal on the hearth of the electric furnace. This could become a serious operating problem when the company increases sulphur dioxide capture, by implementing a more complete roast of the concentrate, to meet Government environmental legislation.

It is estimated that the capital expenditure required for installing an electric arc furnace pilot plant, based on a 250 KVA furnace designed for maximum flexibility, will be in the order of $400,000 to 500,000. No definitive cost estimate for such a facility has been prepared as yet.

The electric furnace project with Falconbridge would take 3-4 months of experimental work after the furnace and ancillary systems are constructed; the total time could thus be 10-12 months. Heat transfer modelling studies to provide data for design of stirring systems will be carried out in parallel, possibly within an Ontario university.

GENERAL

1. PURPOSE OF THE ELECTRIC FURNACE PILOT PLANT

The purpose of the pilot plant electric arc furnace installation is to provide companies in the Province of Ontario with facilities to develop metallurgical data on existing and new electrical arc melting and smelting processes to enhance their competitive position.

2. POTENTIAL APPLICATIONS FOR THE PILOT PLANT FACILITIES

A number of potential research opportunities for the electric furnace pilot plant facilities were discussed. A brief outline of these discussions is given below.

a. Development of a method for overcoming a potentially detrimental metal build up on the hearth of the Falconbridge Ltd. electric furnaces when a higher degree of roast is implemented for increased sulphur dioxide recovery.

b. High voltage application to electric arc furnace smelting.

c. Smelting of spent automotive catalyst for the recovery of precious metals.

d. Furnace feeding technology including feeding of fines through hollow electrodes.

e. Improvements in the grade of calcium cyanide.

f. Alloy Development.

g. Development of methods for reducing electrode consumption.

h. Development of improved sulphide smelting technology.

i. Modelling studies for Stelco's ladle furnaces.

3. FURNACE REQUIREMENTS

3.1 General

In the past electric furnace pilot plants have been designed with one specific application in mind. They were therefore only of limited use. To overcome this limitation, a furnace installation with a great deal of flexibilty is required to meet the needs of the widely diverse application of electric furnaces by different segments of the metallurgical industry. The flexibility has to be built into the electrical system and also into the furnace structure itself. To accomplish this a transformer with a wide voltage and current range is needed. Rather than work with fixed hearth, it is proposed to adopt a system in which different types of hearths can be moved under the electrodes. This configuration is very much like that of a ladle furnace.

3.2 Electrical Requirements

It is proposed to equip the furnace with a single phase 250 KVA transformer having a tip voltage range capability of 40 to 1000 volts, and a current capability of 250 to 6250 Amps. The furnace will be fitted with a self regulating electrode hoist. Electrode clamps should be capable of accepting either 2 or 3 in. dia. carbon or graphite electrodes. The electrode spacing should be adjustable. An additional requirement for the electrode system is to be self supporting to permit the use of various hearth and roof configurations on a quick turn around.

3.3 Furnace Hearths

Different electric arc furnace applications require different hearth designs. For instance, a sulphide smelting furnace needs to be fitted with a deep hearth, whereas a steel melting furnace requires a shallow hearth.

To be able to change from one furnace application to another quickly, it is suggested that the system be designed along the lines of a ladle furnace system, where different ladles, in this case, different hearths can be moved under the electrodes, and fitted with the appropriate types of furnace roofs.

3.4 Auxiliary Equipment

Only a brief listing of the major items of auxiliary equipment required to run the furnace is given below.

a. Feeding system
b. Feed hoppers mounted on load cells
c. Furnace ventilation and gas scrubbers (1000-2000 scfm)
d. Bag house
e. Instrumentation, control and measurement
f. Ladles
g. Ladle and furnace preheat burners
h. Fork Lift truck
i. Storage area for supplies
j. Injection equipment for gas and solids

4. FALCONBRIDGE APPLICATION

4.1 The Problem

Falconbridge Ltd. is required by law to reduce its SO2 emission to the atmosphere by 1994. Several potential approaches to meet the Government's requirements are under study. The most likely one to be adopted involves increasing the degree of sulphur elimination in the fluid bed roasters. They generate a steady stream of SO2 gas which can be readily converted to sulphuric acid. In order to control losses of paymetals to the slag, additions of reductants have to be made to the electric smelting furnaces. The reductant requirements increase as the degree of roast increases. The beneficial effect of the reductant additions is to reduce metal losses to

the slag. However reductant additions increase the metal content of the matte. Since the metal solubility in matte is very much a function of temperature, metal will precipitate out on cold surfaces. Since the furnace hearth is the coldest part of the furnace, metal will deposit on it unless special measures are taken to prevent this from happening. The metal build up, if not controlled, can render the furnace inoperative.

4.2 Potential Approaches for Overcoming the Problem

4.2.1 Increase of the System Temperature

This approach will not only increase the energy consumption per unit of metal produced, but increased refractory wear will most likely also be a problem.

4.2.2 Reduce the Amount of Reductant Addition

This is technically feasible, but metal losses to the slag will increase. This in turn will reduce the profitability of the operation.

4.2.3 Increase in the Furnace Hearth Temperature

There are three approaches by which this can be achieved:

4.2.3.1 Magnetic stirring of the matte to homogenize its temperature.

4.2.3.2 Gas stirring of the matte to homogenize its temperature.

4.2.3.3 Reduce the heat flux from the hearth by either improving its insulation or by introducing auxilliary hearth heating.

4.3 Approach Favoured by Falconbridge Ltd.

Falconbridge is currently favouring the approach which incorporates mate stirring to overcome or control the metal build up on the furnace hearth. They hope to investigate all three approaches outlined above in an experimental furnace.

4.4 Program

Falconbridge is looking at running two programs in parallel to obtain the information required to overcome uncontrolled metal build up on the hearth of the electric furnace.

4.4.1 Model Study

The first program is designed to develop a heat transfer and mixing model using oil and water. It is expected that this model will provide information with regard to where to locate the magnetic stirrers or gas lances in the furnace to obtain a matte phase with a uniform temperature without significantly disturbing the overlying slag and calcine phases. It

is expected that this program is best carried out at a University having staff members with a sound knowledge of heat transfer and scale up from model studies.

4.4.2 Pilot Plant Studies

Pilot plant studies are not only important for testing the validity of the results developed by the model studies, but they are also needed to test the reliability of equipment. Operators will only agree to major changes in plant operating practice after they have been piloted.

It is planned to test the following on the pilot plant scale:

a. Gas Stirring
b. Magnetic Stirring
c. Application of auxiliary heaters to the furnace hearth.

To carry out this work, a furnace crucible with a minimum depth of 4 ft. is required with well insulated side walls to overcome the "wall" effect.

Figure 1 shows the cross section of the Falconbridge electric furnace.

5. COST

5.1 Capital Cost

It has not been possible to prepare a cost estimate in the time available. This needs to be done. Based on past experience, it is expected that the capital cost for the proposed installation will be in the order of $400,000 to 500,000. This assumes that a building to house the plant is available. (Lakeview Plasma R&D Facility).

5.2 Operating Cost

5.2.1 Electric Furnace Pilot Plant

Assume 3 months operating time.

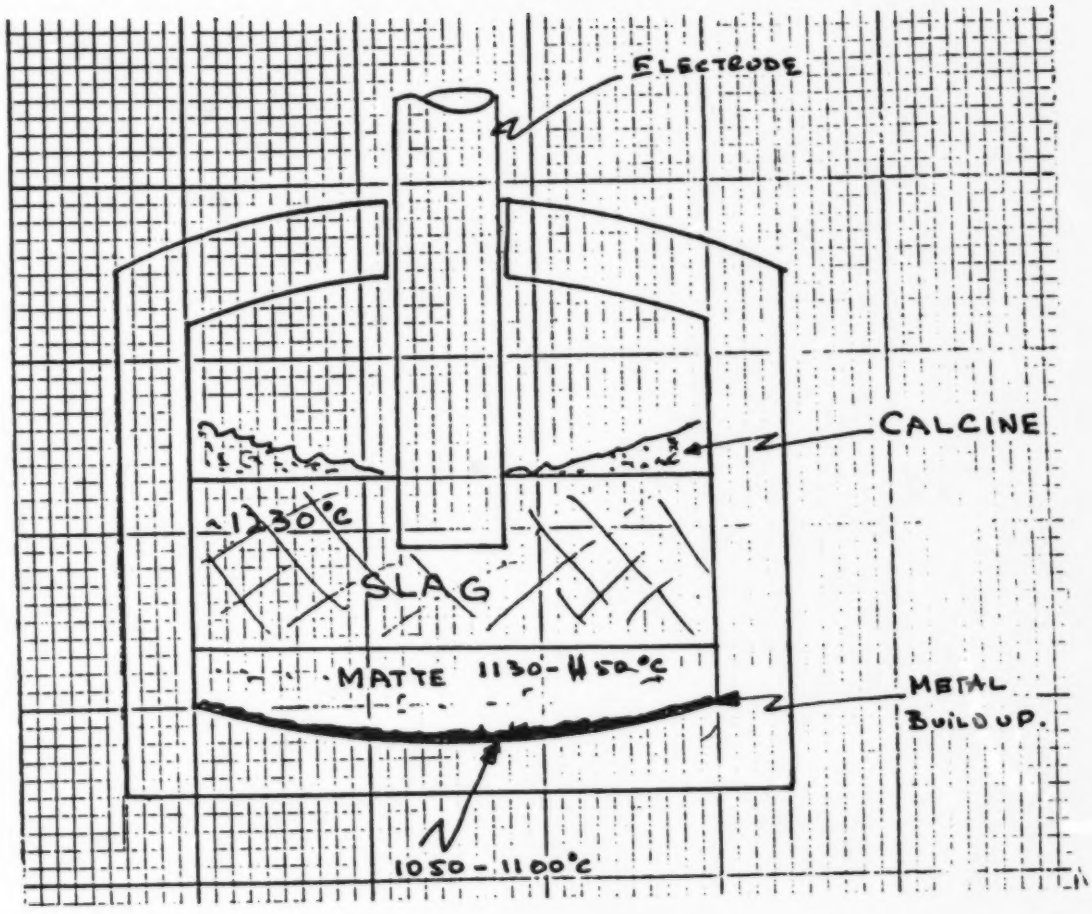
	$ Can
Engineers 3 at $80,000/year	60,000
Technicians 2 at $60,000/year	30,000
Supplies, power, misc.	15,000
TOTAL	105,000

5.2.1 Model Study (1 year program)

Students, 2 part time @ $8,000	16,000
Supervising Professor	6,000
Materials	5,000
TOTAL	27,000

R. Bergman
Consultant
Process Metallurgy Study

FIGURE 1 SCHEMATIC CROSS SECTION OF THE ELECTRIC ARC FURNACE



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